PATHOLOGY OF THE LYMPHATICS OF THE PERITONEUM.

By BYRON ROBINSON, M.D.,

OF CHICAGO.

PERITONITIS is lymphangitis. The pathology of the lymphatics of the peritoneum is a most important factor, as in the structure of the peritoneum lymphatics represent the peritoneal absorbents. On the behavior of the lymphatics of the peritoneum towards invading infections depends the life of the subject. Should the lymphatics absorb the infectious invaders as rapidly as it would water, the patient would rapidly succumb to sepsis. Hence the peritoneal exudate which obstructs the lymphatics saves the subject from rapid death. Doubtless this explains the dictum of older physicians when they announced puerperal fever with peritonitis (exudates) and puerperal fever without peritonitis (absorption). In the first case the peritoneum was attempting to defend itself with exudative barriers and blocking of the lymph-channels with the same, so as to check further absorption and save life. In the second place, the peritoneum, in meeting suddenly the virulent invaders, was insufficiently prepared with its leucocytal army to withstand the attack, and hence rapid lymphatic absorption with fatality. It may be said that the peritoneal endothelia are connective-tissue cells, and that connective-tissue cells are analogous throughout the body. Hence the original connective-tissue cell is not altered in function or structure by becoming endothelial cell. The membranous character of (endothelia) connective-tissue cells does not denote an organic independence. The endothelia are derived immediately from the general connective-tissue cells of the body. The peritoneum is a layer of flattened connective-tissue cells whose surface is not interrupted by any other or foreign elements. The peritoneum is an interstitial space,—

a fissure in the general connective-tissue masses. Hence, in regard to endothelia in function (physiology) and structure (anatomy), we are dealing with connective-tissue cells, and the pathology of such cells is similar in different portions of the body. Connective-tissue cells assume many shapes, as stellate, spindle-shaped, and flat (endothelia). The endothelia may and do share in all the morbid changes to which the interstitial connective-tissue cells are liable.

The significance of these remarks are apparent, when it is remembered that the endothelia, flattened connective-tissue cells, form the lining membrane of the peritoneal lymphatics. A factor in the active invasion of peritonitis (lymphangitis) is the gliding of one segment of the peritoneum on the other. One surface of the peritoneum actually rubs the infection into the other, and the inflammatory process spreads by friction (trauma) and contiguity, the physiologic expansion and contraction of viscera and consequent friction of opposed endothelial surfaces contribute vigorously in extension of the peritonitis or lymphangitis. Peritonitis might be appropriately termed lymphangitis. The lymphatics of the peritoneum are peculiarly liable to continuous or spreading inflammation, because they are not interrupted for large areas. The lymphatics in other areas of connective tissue are interrupted by fasciæ, muscle, bone, and other foreign elements or barriers. However, it is claimed that the peritoneal connective tissue resists pathogenic microbes more than other connective tissue. The manifest effect of lymphangitis (peritonitis) is leucocytal emigration, hyperæmia, congestion, exudation, and endothelial desquamation. After the excessive physiologic manifestation of leucocytal defence and change in fulness and calibre of vessels, the earliest phenomenon of change is evident in the endothelium. As the peritoneal lymphangitis progresses, the endothelia desquamate, and leave various sized pits. It appears that the endothelial cells are forced out of their bed by the enormous transudation. The interstitial spaces, lymph-channels, and capillaries immediately beneath the endothelial membrane are not only highly distended, but the transuded fluid aids in elevating or tearing from their beds the endothelial cells. The desquamated endo-

thelial cells and leucocytes, with other forms of cells, float about in the transudent peritoneal fluid. The gross appearance of the peritoneum subject to lymphangitis is that the membrane is hyperæmic, reddened with blood, and the capillaries are engorged with blood. The endothelial surface has lost its natural pearly or glistening, polished surface, owing to the desquamated endothelia. A grayish, soft, elastic substance lies loosely on the peritoneal surface or extends in the form of bands from one peritoneal surface to the other. If the lymphangitis is recent, considerable fluid exists, containing ragged flakes of lymph. Microscopic examination of this inflammatory product shows it to consist of coagulated albumen, cells, and nuclei. The nuclei and cell protoplasm may become separated. The detached cells continue to proliferate, producing new masses of nucleated protoplasm by division. The endothelial plate, separated from its nucleus, may be seen floating about in the peritoneal fluid. Inflammation of the lymph-vessels is chiefly caused by abnormal lymph contents. They become inflamed from adjacent fields by continuous spreading of infectious process in similar tissue. In simple lymphangitis the remarkable changes, color, rubor, tumor are situated in the tissue immediately surrounding the endothelial lymph wall; this is perilymphangitis and paralymphangitis. The simplest lymph-vessels consist of an endothelial tube. The inflammation may be in the endothelia which compose the wall of the vessel. In such case the endothelia become thickened, swollen, and granular. The lighter inflammatory forms may resolve and recover, but the severe forms may become suppurative (lymphangitis purulenta). When lymphatic suppuration and abscess exist, the highly swollen lymph-vessels with slackened walls often contain lymph thrombi, which block the vessels and prevent further spread of infectious material. The contents of the vessels may be fibrinous masses, mixed with micrococci or pus collections. The contents of the vessels may infect the adjacent walls, producing thrombo-lymphangitis. A thrombus may become fragmented, whence it becomes an embolus, and may float on to various localities through the lymph-stream, not only blocking the lymph-vessels, but also infecting them. Thrombo-lymphangitis may so alter and

change the lymph-stream that it will flow in contrary directions than natural, and hence infect odd regions or regions in opposite directions to the natural lymph-current. This is either due to backing up of the lymph-channel, and thus forcing the lymph-stream backward, or the pathogenic microbes thrive and travel on the lymph-channel walls in a direction contrary to the lymph-current. A continuous lymphangitis may arise and progress in a lymphatic trunk. The process may thicken the walls and especially obliterate the vessel lumen at the valvular constrictions. Tubercular lymphangitis is apt to occur in the small lymph capillaries, because here the lymph-current is small and slow, allowing ample time for the tubercle bacillus to grow and multiply,—*e.g.*, omentum majus. The peritoneal lymph stomata absorb blood, pus, or any fluid without regard to composition. When the peritoneal lymph-vessels become attacked in any locality their destruction, on becoming obstructed by thrombi, is the method by which the general peritoneum or organism is protected. Artificial drainage in peritoneal lymphangitis is a life-saving process. Flushing in local peritoneal lymphangitis is a dangerous process, as it floats the germs or their products into new fields, where the peritoneal lymphatic mouths stand ready to absorb. In the old field of peritoneal lymphangitis the lymphatic channels become obstructed by thrombi, hence the general peritoneal lymphatics were saved by local destruction or by crippling of the lymph-vessels.

The coagulated albuminous substance found in the peritoneum in lymphangitis is an essential constituent of the inflammatory exudate. The high degree of tension, to which the lymph-channels are subject during inflammation, induces an exudation of an albuminous fluid. The fluid resembles liquor sanguinis, and it rapidly passes into a solid state, and may be termed fibrinous exudate. Fibrinous exudate implies that the fibrin of the blood exudes from the peritoneal blood-vessels. The lymph-vessel contents are derived from the blood, the fibrinous exudate, together with the liquor sanguinis, appears on the peritoneal surface, and sooner or later is transformed into a solid plastic mass of reddish-gray color. The lymphangites of the pelvic peritoneum are very apt to be circumscribed,

because of the non-absorptive character of the pelvic peritoneum. Considerable microscopic labor on the pelvic peritoneum demonstrated that it was very rich in capillary lymphatics, but poor in large lymph-trunks and stomata. The smaller lymph-vessels and capillaries of the pelvis become much more rapidly obstructed than the larger lymph-trunks of the diaphragmatic or enteronic area of the peritoneum, where larger lymph-trunks and numerous stomata exist ready for rapid absorption. The early and rapid circumscription of peritoneal lymphangitis by obstruction of the adjacent lymph-channels and stomata is what saves so many lives in pelvic peritonitis.

When a fluid is injected into the peritoneal cavity containing very virulent microbes, leucocytosis is very limited. The leucocytes appear unable to cope with the dangerous microbe. The microbes and the leucocyte-cells remain quite separate. If the microbes injected in the peritoneal cavity be of a less virulent character, they begin to adhere or stick to the leucocyte-cells, especially to the hyaline-cells. Leucocytosis is slight in comparing with virulent peritoneal microbes. The peritoneal fluid sometimes, even to sixty minutes after artificial injections of microbes, becomes free or almost free from cells,—leucopenia (Metchnikoff, Kanthack, Hardy, and Durham), because the cells, peritoneal cells, become disintegrated; the same condition occurs in the pleural cavities subsequent to injections as well as in the blood, and the process has been attributed to cell-destruction or, perhaps better, arrested in the organism. The lymphocyte-cells, however, always remain in the peritoneal fluid. The chief organ that the cells of the peritoneal fluid seek and become attached to is the mesogastrium (the omentum). This is in accord with the fact that the mesogastrium is a great peritoneal protector. In nearly all my experiments, when peritonitis or congestion arose, the most intense congestion appeared in the mesogastrium. In deaths from peritonitis, man or animal, this intense congestion of the mesogastrium is a characteristic feature. The mesogastrium in rabbits, dogs, and guinea-pigs becomes rolled up along the greater curvature of the stomach. In the larger mesogastrium of man one can detect local patches of more intense congestion in peritonitis.

The rolling up condition of the mesogastrium in peritonitis is no doubt due to two factors,—*viz.*: (*a*) the peristaltic movements of the tractus intestinalis,—in man specially the peristalsis of the enteron; (*b*) the sticky and adherent condition of the mesogastrium in peritonitis enables it to stick when folded by the motus peristalticus. Violent and disordered peristalsis rolls the mesogastrium without peritonitis, but, its surface being not sticky or adherent, it unrolls. The mesogastrium in peritonitis attempts to corral the hyaline-cells with their adherent microbes by picking the cells out of the peritoneal fluid and making them adhere to its sticky surface; this process makes the cells in the peritoneal fluid much less in number. Careful examination of the mesogastrium will show that it harbors microbes while the peritoneal fluid is sterile. The surface stickiness of the cells determine their "balling" and the adherence to the mesogastrium. However, if the microbe be very virulent, the stickiness of the surface of the cell will not suffice to ensnare and destroy it. Cells suspended in fluid, perhaps, cannot act so vigorously as when localized in endothelial surface. Cells cannot destroy as many microbes while suspended in fluid, as they may only meet the microbe by chance, and also the microbe is not so liable to adhere to the cells. When cells have reached the endothelial membrane (mesogastrium) they are able to be aggressive on the microbe by their own power of movement. Leucocytes apparently instinctively wander to points of peritoneal irritation. Starling has aided chiefly in placing the flow of lymph in the peritoneal cavity on a secure physical base. There appears to be a general definite relation between lymph-flow and cell-intrusion in the peritoneal space. For example, Durham states that, during the leucopenic stage, the amount of peritoneal lymph increases and decreases for several hours subsequent to the peritoneal injection. In virulent peritoneal injections the lymph-flow increases with perhaps diminished absorption until *exitus lethalis* (*e.g.*, fifteen hours). In virulent peritoneal injections, which do not cause death, the increased flow of lymph begins to diminish after the first twenty hours, and towards the third and fourth day the lymph becomes viscid and small in quantity. In some experiments, after kill-

ing the animal, merely a moist peritoneal surface could be observed. There is little doubt in my mind, after my own numerous experiments in the peritoneal cavity, that the lymph-channels remove microbes and cells rapidly and extensively from the peritoneal cavity. This view of the lymph-channels being the chief pathway of exit from the peritoneal cavity is confirmed by Von Recklinghausen's examination of the diaphragm after fatal puerperal sepsis. He found the diaphragmatic lymphatics in the serosa intensely infected. Dr. Herbert E. Durham, in his excellent labors on the peritoneum, made observations on thirty fatal cases of peritonitis in man. He demonstrated that the glands at the crura of the diaphragm (mediastinal) are always more or less affected. They were swollen, reddened, and contained microbes. The microscopical examinations of the mediastinal glands in autopsy will disclose the kind of microbe which proved fatal to the subject. Peritoneal ascites, dropsy, is doubtless a form of peritonitis involving the peritoneal lymphatics. However, the physiologic factors of its causation are not very clear. Peritoneal ascites is simply an excessive accumulation of lymph in an interstitial space (peritoneum). The excessive accumulation of lymph in the peritoneal cavity must be attributed to the secretion of the endothelia of the lymph-vessels or that it is a filtrate under pressure. Ludwig found that an increase in capillary pressure increased the supply of lymph. Starling, in his excellent labors on peritoneal ascites, considers carefully the complicated etiology. The factors of ascites peritonei may be—

(1) Increased transudation:
- (*a*) increased capillary pressure;
- (*b*) venous obstruction;
- (*c*) plethora;
- (*d*) increased permeability of the vessel walls;
- (*e*) local injury by
  - mechanical irritants,
  - thermal irritants,
  - chemical irritants;
- (*f*) malnutrition;
- (*g*) watery condition of blood.

(2) Diminished absorption:
- (*a*) by lymphatics;
- (*b*) obstruction of lymphatic trunks;
- (*c*) venous obstruction;
- (*d*) watery condition of blood;
- (*e*) concentrated transudations.

The form of dropsy, which is the simplest in pathology, is that due to venous obstruction. It would be natural to ascribe dropsy to an increased lymph-production in consequence of increased capillary pressure behind the obstruction. Experiments show that the etiologic factors are not so few and simple.

The most constant glands affected are those in the mediastinal space adjacent to the mammary vessels. The anterior mediastinum lymph-paths are the chief routes taken by the material leaving the peritoneal cavity, as any one can prove by animal experimentation or examination of their structures in humans after death from peritonitis. The lymphatics in the diaphragm of guinea-pigs and rabbits injected with Berlin blue show numerous granules. In short, the lymphatic channels and lymph-nodes leading from the peritoneum through the diaphragm and mediastinum to the thoracic duct are crowded with blue granules in those animals which were subject to peritoneal injections of Berlin blue. Durham states that in tuberculous peritonitis the glands of the anterior mediastinum are enormously enlarged and infiltrated with tubercular matter. This statement corroborates the results of my numerous experiments that the paths of exit from the peritoneal cavity are by way of the lymphatics, and that peritonitis affects chiefly the lymphatics,—in other words, peritonitic lymphangitis. If the diaphragmatic and mediastinal lymph-tracts are not conspicuously infected in lymphangitis (peritonitis), some injection of the abdomen should be made to see if the mesogastrium or some pathologic factor has not intervened to obstruct the natural way of the lymph-channels. Amply sufficient indirect lymph-routes for fatal exit may exist without the direct route of the centrum tendineum. An examination of the mediastinal lymph-channels or nodes may prove the existence of lymphan-

gitis (peritonitis) without inspection of the peritoneal cavity. Rapid death following peritoneal sections or rupture of strictures allowing large quantities of virulent material to pass into the peritoneal cavity is doubtless due to violent and overwhelming infection of diaphragmatic lymphatics. I have seen a woman die in six hours after the rupture of a pyosalpinx into the peritoneal cavity. In this case, which I post-mortemed, the enteron manifested signs of severe irritation. Since a dog's peritoneum will absorb in half an hour 10 per cent. of his body-weight, the woman had ample time in six hours to be overwhelmed with absorbed infection. Lymphangitis had not had sufficient time to develop. Lymphangitis (peritonitis) is what tends to save life by obstructing the lymph-paths and preventing absorption of infection material. Cases reported as death from shock, eight to twenty-four hours after operation, are no doubt patients overwhelmed by absorbed infecting material let loose by operation in the peritoneal cavity. It must be remembered that after death from lymphangitis (peritonitis) in the post-mortem room one is liable to observe pints of pus. In really acute cases of lymphangitis—*i.e.*, cases which have absorbed much infection—relatively few macroscopic traces remain. Lymphangitis saves life, lymph-absorption kills. The pumping action of the diaphragm determines, to a certain degree, a current towards the centrum tendineum, and hither flows whatever lies in the peritoneal cavity. Some authors believe that the leucocytes which migrate to the peritoneal cavity to protect it against invasion migrate from the blood; others state that such leucocytes migrate from the interstitial spaces. The leucocytes migrate into the peritoneal cavity fifteen minutes post-injection. A relatively few experiments in injecting Berlin blue solutions into the peritoneal cavity demonstrate the rapid employment of lymph-paths for peritoneal exit. Also the rapid forcing of the lymph-paths into service for peritoneal exit of fluids is closely connected with the participation of leucocytes. These views bring out the close relation of the cœlonnic cavity (interstitial space) and the lymph-paths to the blood, on the one hand, and the blood-vessels with the cœlonnic cavity on the other,—*i.e.*, blood-vessels, peritoneum, and interstitial spaces are in very intimate relations with each other.

The reason that the pelvic peritoneal inflammations (lymphangitis) are so tolerated is that they generally arise slowly, thus giving time for obstructions in the lumen of the pelvic peritoneal lymphatics to arise. Also because the lymph stomata of the pelvis are much less numerous than the stomata of the upper end of the peritoneum (diaphragm). The lymphatics of the pelvic peritoneum do not absorb so rapidly as those of the diaphragmatic peritoneum.

Besides the dangerous infective area in the peritoneum is that of the enteron, where the lymph-channels are very numerous and stomata numerous, though much less than in the centrum tendineum. The enteron is not an area of lymphangitis (peritonitis), but one of absorption. The benign area of lymphangitis (peritonitis) is that of the colon, and is explained by the limited lymph-channels and stomata. Peritoneal surgery today is successful and brilliant in the benign colonic area (*i.e.*, the area of the pelvic organs, appendix, stomach, gall-bladder, and kidneys), but many dismal failures still occur in the dangerous enteronic area (enteron and pancreas). In animals which recover after non-fatal doses of peritoneal injections there is a widespread peritoneal leucocytosis, and Durham asserts that such stage is followed also by the appearance of macrophages. The object of the macrophage is doubtless to invest microbes, to imprison and sterilize them, to check their movements by sticking to them. Durham thinks that the macrophage is not of hæmal origin, but produced locally, especially on the mesogastrium. Since the leucocytes and macrophages appear in such vast numbers in the peritoneum of recovering animals, it is fair to assume that they have a share in combating peritoneal infecting. Issaeff demonstrated a general principle of peritoneal immunity when, after he had injected the peritoneum with solutions of NaCl, urine, serum, etc., he was able to observe that it protected the animal against certain pathogenic microbes for a certain length of time. In short, peritoneal leucocytosis is produced. Leucocytes, macrophages, are the agents which give peritoneal immunity. But any local peritoneal irritant which produces a leucocytosis produces a general immunity for only a certain length of time. It does not produce a spe-

cific resisting power, like vaccination. In general, a local irritant on the peritoneum produces a leucocytosis,—*i.e.*, a superior microbic protecting agent. But a specific bacterial protecting agent for the peritoneum must be one which, like vaccination, will produce an indefinite immunity. In the surgery of the peritoneum—*i.e.*, in peritoneal lymphangitis—Issaeff's demonstration of a period of general increased resistance, by a local peritoneal irritant, may be of clinical value Issaeff showed that any local peritoneal irritant would produce leucocytosis, which is the body-guard of animal life. Leucocytosis begins with intraperitoneal injections, continues until the animal recovers. The white corpuscles which migrate into the peritoneum, the leucocytes, are not the only source of new tissue, if it be formed, but may be the source of pus. It was the view of Cohnheim that the white corpuscles, the leucocytes, were the source of the new tissue. He was supported by Ziegler, Heidenhein, Senfleben, Tillman, Schack, Bizzozero, and Aufrecht. This view is opposed in part by Baumgarten, Hamilton, Weiss, Ewetzky, and Böttcher. Perhaps the majority of modern investigators oppose Cohnheim's view. Sherrington and Ballance conclude that new tissue comes from plasma-cells, which are the source of tissue-repair. Plasma-cells, a cell distinguishable from the white corpuscle of the blood, build and repair. The plasma-cell proliferates rapidly in new formations. Plastic substance, to build up, must secrete cells which will end in a fibrillar substance. Injured tissue excluded from the atmosphere seldom suppurates; it repairs itself.

It would appear that the peritoneal lymphatics decrease in size, if not in number, from fish to man. The lymphatics of the peritoneum are prominent agents in the dissemination of disease. Tuberculosis becomes widely spread through the lymphatics. According to Burdon Sanderson, there is a form of adenoid tissue in the peritoneum which, during peritoneal tuberculosis, becomes greatly proliferated into cords and nodules. Naturally the peritoneum has on it localized patches of germinating endothelium; in a state of chronic inflammation, as tubercular lymphangitis (peritonitis), these patches of germinating endothelia become very large and proliferate very

actively. Klein reports that when the material of a tubercular gland is injected into the peritoneum of a guinea-pig, germinating endothelia spring up vigorously around the stomata of the centrum tendineum and on the omentum. The experiment demonstrates that there is a current in the peritoneal cavity directed towards the diaphragm, and also that it is the stomata or lymphatics which tubercular bacilli attack. In other words, the lymphatics of the peritoneum fight its battles in disease. In lymphangitis of the peritoneum the safety of the subject lies in obstruction of their lumen or external drainage.

The share that lymphatics assume in peritonitis is important to every physician.

There is a well-recognized principle prevalent among physicians that if a subject recovers from local peritonitis or lymphangitis subsequent attacks in the same locality are passed with less danger. In the adult there exists certain localities of peritonitis which are practically constant. During the past fifteen years I have performed over 500 abdominal post-mortems, and approximally the local peritonitis or lymphangitis may be calculated as follows,—viz.:

(*a*) Peritonitis over the right psoas muscle, which involves the peritoneum of the appendix, cæcum, or distal end of the ileum, amounts to some 75 per cent. of subjects.

(*b*) Peritonitis over the left psoas muscle chiefly involving the mesosigmoid to about 80 per cent. of subjects.

(*c*) Lymphangitis over the levator ani muscle in females amounts to about 80 per cent. of subjects.

In female subjects the accessory factors of pelvic peritonitis due to the trauma of the levator ani are two,—viz., (*a*) escape of infection from the proximal end of the oviducts, and (*b*) the contraction and dilatation of the rectum aiding the escape and distribution of infection. (*c*) The lymphangitis about the gall-bladder region is 40 per cent. of subjects. (*d*) There is 90 per cent. of lymphangitis about the spleen of adults.

Local peritoneal lymphangitis is chiefly due to muscular trauma. The pelvic lymphangitis is partially only due to the

trauma of the psoas muscles. In the right iliac fossa the trauma of the psoas is responsible for appendicitis in the large numbers of cases. About the gall-bladder the trauma of the diaphragm, right crus of the diaphragm, and the abdominal muscles tell the story.

The spleen is traumatized, resulting in perilymphangitis, by the diaphragmatic muscle chiefly.

These local areas of lymphangitis are covered with endothelia similar to the adjacent portions of the peritoneum. However, the portions of the peritoneum over which lymphangitis has passed one or more times appear pearly white, hard, and shiny.

Careful microscopical examinations of pieces of the areas of local lymphangitis revealed the anatomic fact that the lymph-vessels were almost entirely obliterated. White connective tissue had proliferated and constricted until but few lymph-vessels were found in the field. The obliteration of the lymph-channels from the peritoneal membrane by constriction of cicatricial tissue explains why the repeated lymphangitis became less and less dangerous.

Obliterating the lymph-channels in the peritoneum left no means to transport the infectious material.